RECONSTRUCTION OF PAST CLIMATIC PROXY SERIES

John E. Kutzbach

Wisconsin University

Prepared for:

Air Force Office of Scientific Research
Advanced Research Projects Agency

29 August 1975

FINAL TECHNICAL REPORT

"Reconstruction of Past Climatic Proxy Series"

Submitted to

DEPARTMENT OF THE AIR FORCE
Air Force Office of Scientific Research (AFSC)
1400 Wilson Boulevard
Arlington, Virginia 22209

29 August 1975

Principal Investigator: John E. Kutzbach
Phone: (608) 262-2339
Center for Climatic Research
Institute for Environmental Studies
1225 W. Dayton St.
University of Wisconsin, Madison, WI 53706

Program Manager: William J. Best
Phone: (202) 694-5454

Effective Date: 1 July 1974
Expiration Date: 30 June 1975
Amount of Grant: $101,158
Grant No: AFOSR 72-2407
ARPA Order: 2221-3
Program Code: P10
Contract No: F44620-75-C-0055

Sponsored by
ADVANCED RESEARCH PROJECTS AGENCY

UNCLADDIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR - TR - 75 - 1361	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) RECONSTRUCTION OF PAST CLIMATIC PROXY SERIES		5. TYPE OF REPORT & PERIOD COVERED Final Technical Report 7/1/74 - 6/30/75 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John E. Kutzbach		8. CONTRACT OR GRANT NUMBER(s) F44620-75-C-0055
9. PERFORMING ORGANIZATION NAME AND ADDRESS Center for Climatic Research 1225 W. Dayton Street Univ. of Wisconsin, Madison, WI 53706		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62706E 75-0196 AO 2221-3
11. CONTROLLING OFFICE NAME AND ADDRESS Advanced Research Projects Agency/IPT 1400 Wilson Boulevard Arlington, VA 22209		12. REPORT DATE 29 August 1975 13. NUMBER OF PAGES 47
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Air Force Office of Scientific Research/NP 1400 Wilson Boulevard Arlington, VA 22209		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

past climates, climate change, pollen, tree-rings, varves, Holocene, calibration functions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Reconstruction of past climates from pollen data, tree-ring data and historical data is described. The pollen-climate relationships cover the past 10,000 years and deal with North America and portions of Eurasia. Detailed climatic information from 1000-year records of annually laminated lake sediments and tree-ring records in central North America (Great Lakes area) is also described.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1. Introduction

Our research effort in reconstructing past climates is divided into four categories:

1) Development of data banks on past environments.
2) Development of calibration functions to make possible the interpretation of environmental change in terms of changes of climatic variables.
3) Reconstruction of spatial patterns and time series of past climates.
4) Interpretation of past climates.

The focus of our efforts is the Holocene, approximately the past 10,000 years, for which pollen records, tree ring records, historical records and instrumental records are sources of information (see Fig. 1) Four specific projects are reported here:

1) Pollen records of the last 11,000 years - obtained from lake sediments - dated with radiocarbon.
2) Pollen records of the last 2000 years - obtained from annually laminated lake sediments - dated by counting.
3) Tree core records of the last 200-300 years.
4) Historical (non-instrumental) records.

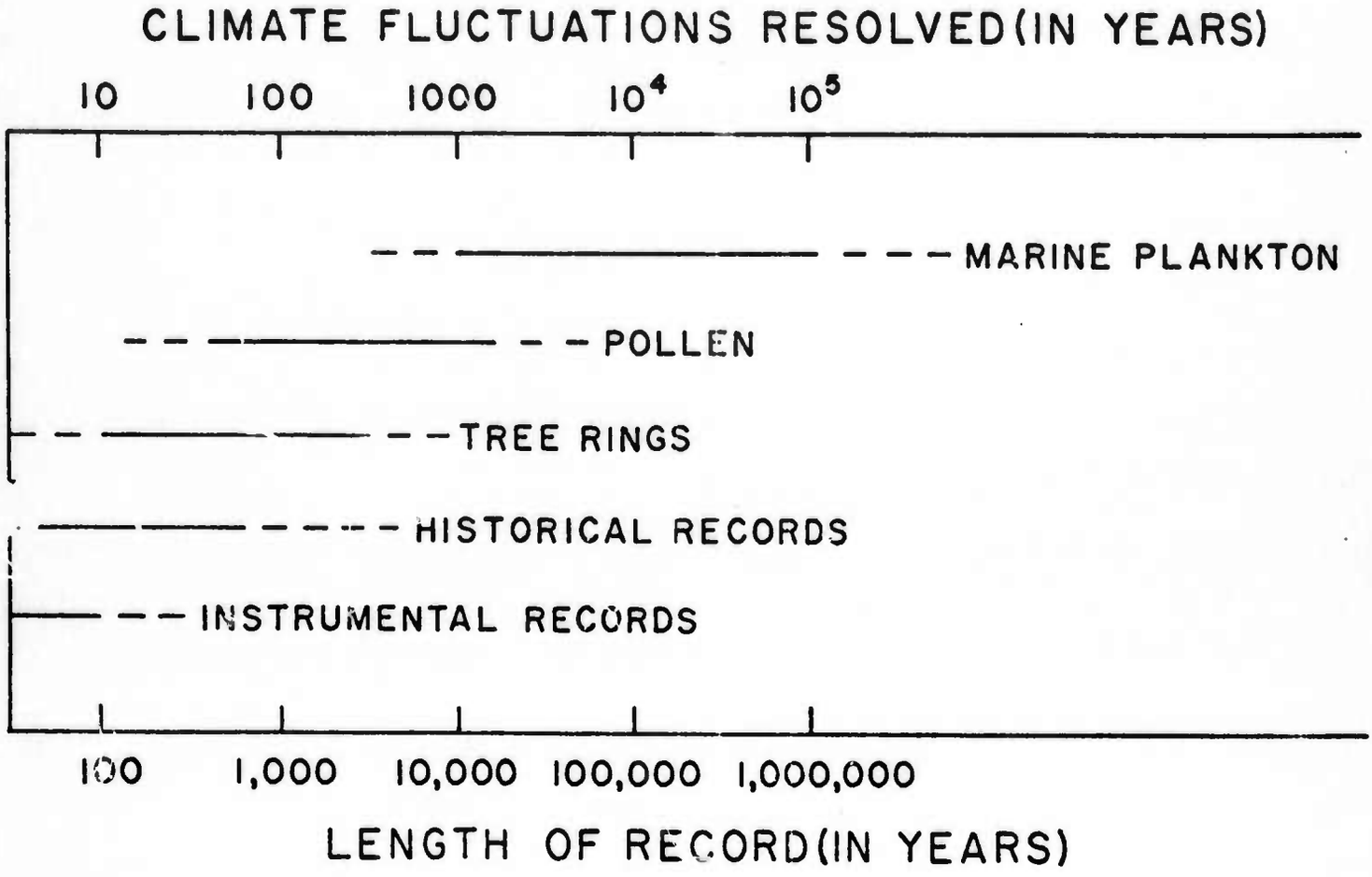


Figure 1. Sources of quantitative climatic information over certain time scales and levels of resolution. Note the critical position of pollen data in its coverage of the Holocene with resolution between 10 and 1000 years.

These four projects are described in detail in our research proposal (1 July 1974 - 30 June 1975) and their current status is summarized below.

2. Current Status

2.1 Pollen records (the last 11,000 years)

The long-term goal of this project is the reconstruction of the major climatic patterns of the Holocene for all the continents. This task is too large for any one institution and therefore requires the coordinated efforts of many individuals and groups. Our initial efforts have focused on Eastern North America, the Soviet Union and India (reported below). In addition, we are collaborating with Dr. H.J.B. Birks, Botany School, Cambridge, England, who is working with the pollen records from Western Europe. Thus, we have made substantial progress toward defining the patterns of Holocene climate for the mid-latitudes of the Northern Hemisphere. With this data set, it should be possible (for example) to estimate changes in the amplitude and wavelength of the long waves in the westerlies at various times in the Holocene. With experience gained in these projects, we hope to continue to be involved in the extension of these studies to the entire globe - including cooperative studies with the CLIMAP group (which is reconstructing oceanic conditions for various past climatic states). Figure 2 shows a generalized version of the global distribution of radiocarbon-dated pollen cores.

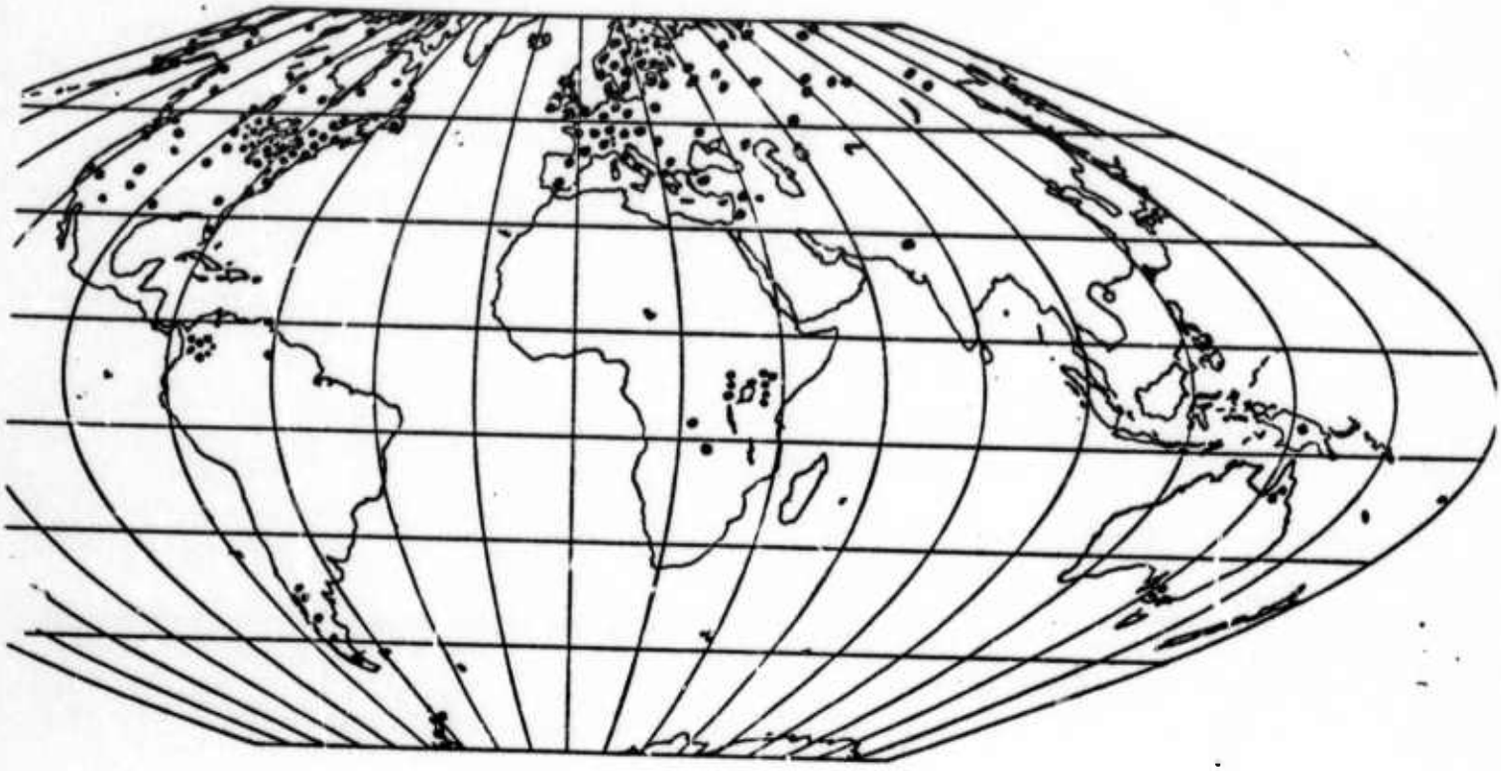


Figure 2. Map showing the generalized distribution of radiocarbon-dated pollen cores around the globe. This map is neither totally complete nor exactly accurate but is designed to show the general current coverage of sites.

a) Eastern North America (T. Webb III)

Using all available radiocarbon-dated fossil pollen cores from Eastern North America, maps have been prepared showing the changing patterns of the various pollen types at 1000 year intervals over the past 11,000 years. Maps for spruce, pine, oak and total herb pollen have been drafted for 11,000; 10,000; 9,000; 8,000; 7,000; 4,000; and 2,000 years ago. Difference maps have also been prepared showing the changes in pollen-type distribution from one interval to the next. Finally, these maps are being used to trace the migration of ecotones during the Holocene.

Figure 3 shows the movement of conifer forest - tundra (A), deciduous forest - conifer-hardwood forest (B), and prairie border (C) ecotones, based upon analysis of C-14 dated pollen cores in Eastern North America. Isolines are labelled in thousands of years before present. Thus, figure 3A illustrates the northward retreat of spruce forests between 11,500 and 8,000 years ago; figure 3B illustrates the northward movement of deciduous forests between 10,000 and 7,000 years ago, figure 3C illustrates an eastward movement of the prairie border between 11,000 and 7,000 years ago, followed by a westward movement between 7,000 and 2,000 years ago. A manuscript describing these maps is now near completion.

A network of some 900 pollen surface samples (Fig. 4) is now available for Eastern North America for use in calculating the calibration functions that transform the pollen data into estimates of climatic parameters. The task of calculating these calibration functions is underway.

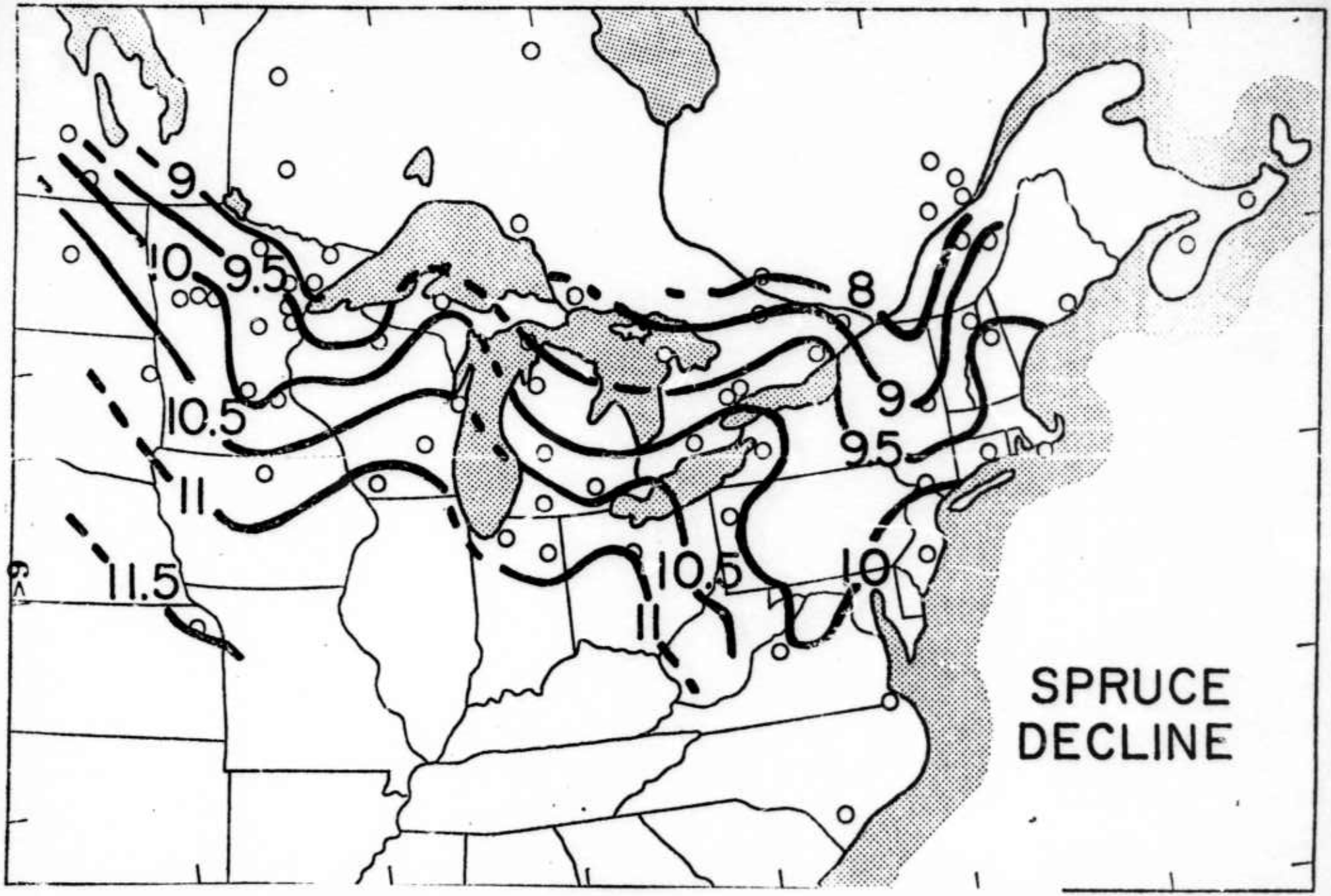


Figure 3a. - Movement of conifer forest-tundra ecotone (isochrones are in thousands of years).

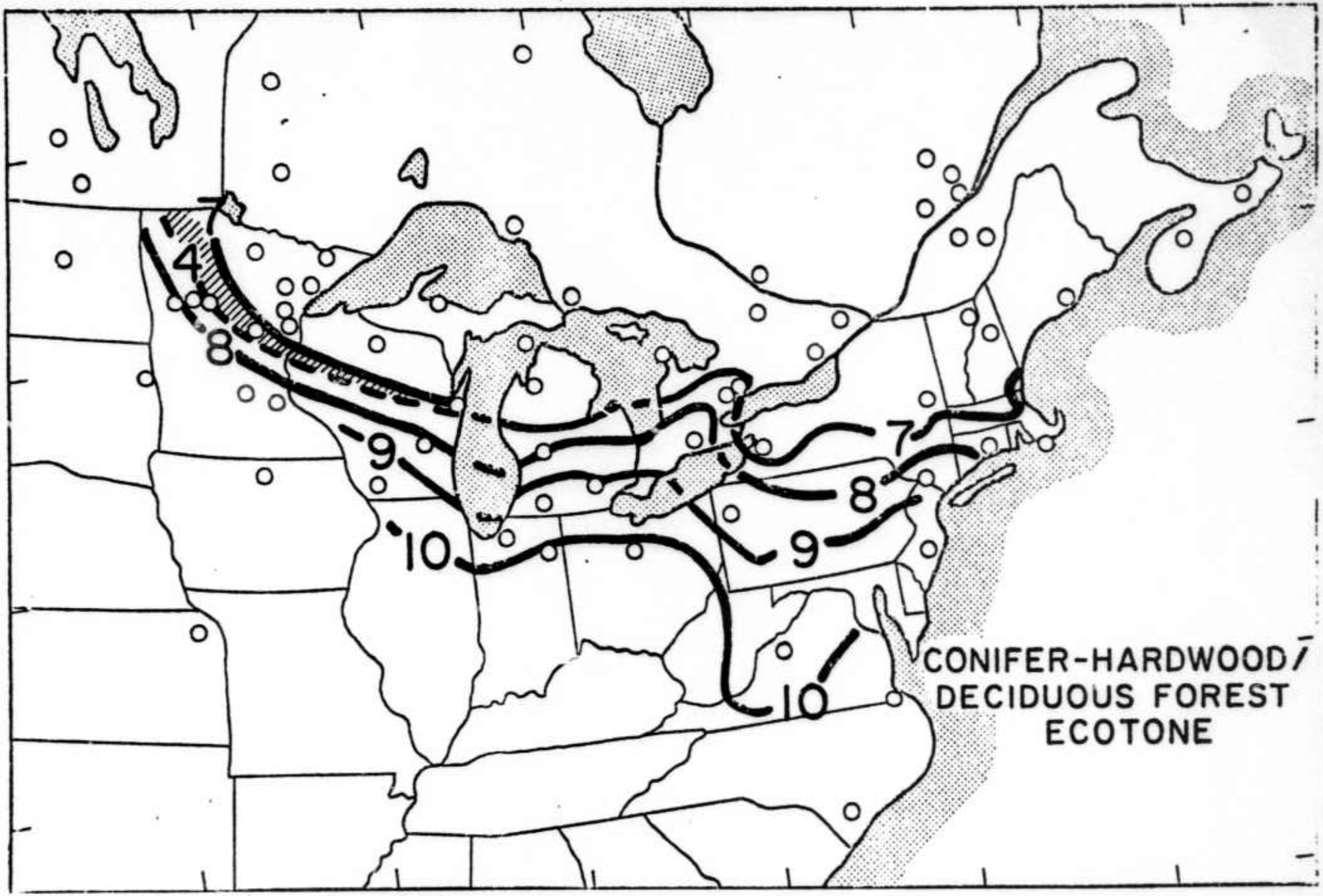


Figure 3b.- Movement of deciduous forest - conifer-hardwood forest ecotone.

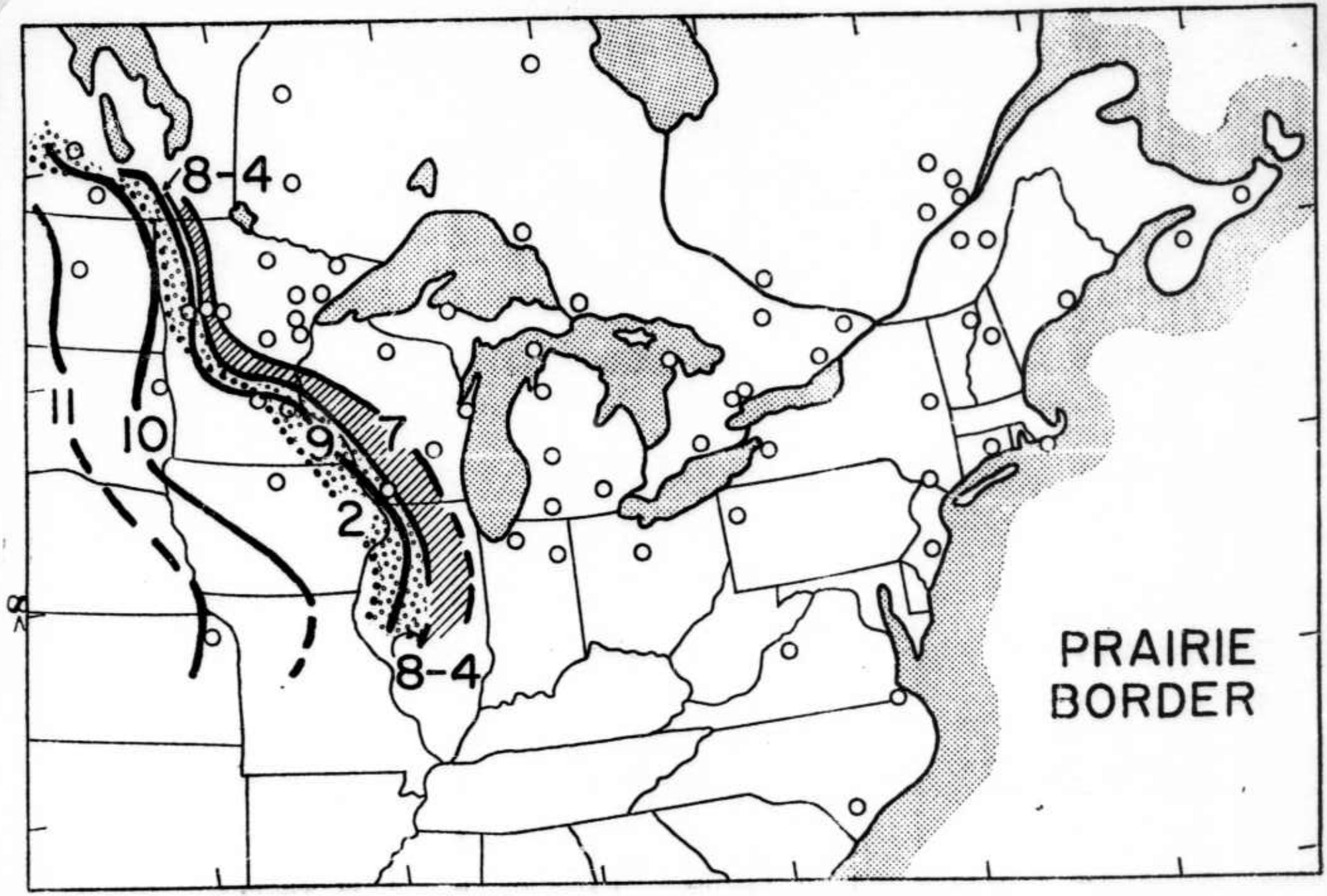


Figure 3c.- Movement of prairie border ecotone.

Figure 4. Location of samples of modern pollen data in eastern North America

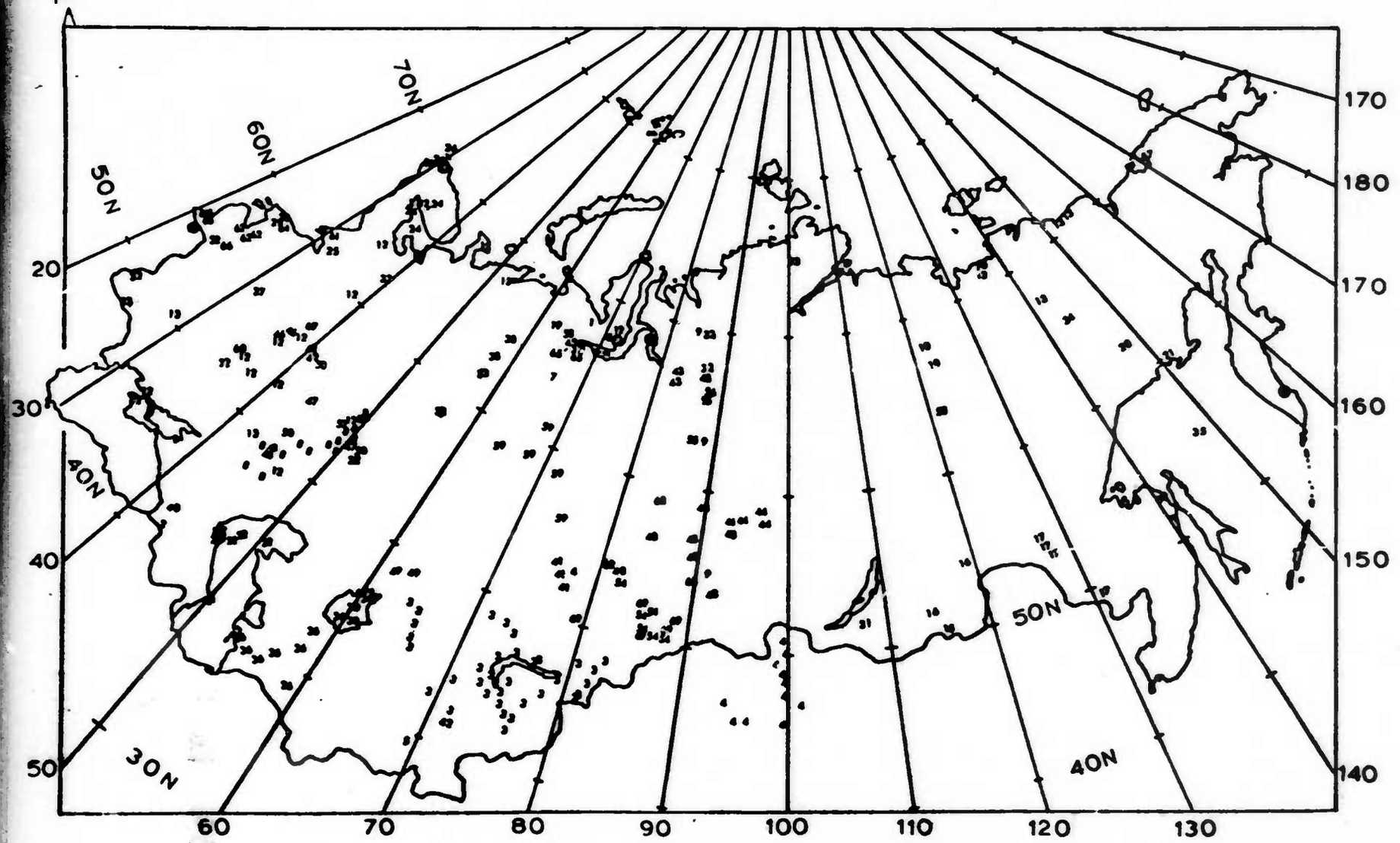
b) Soviet Union (G.M. Peterson)

This work has consisted initially in library research, reviewing Soviet and American bibliographies to determine the amount of information available on Holocene palynology in the Soviet Union. There is an abundance of pollen data for the Holocene, particularly for the European USSR, including surface samples, pollen diagrams, and radiocarbon dates. Approximately 100 published references were obtained with surface pollen data for over 700 locations in the USSR (see figure 5). During the past year we have produced preliminary maps of modern surface pollen for the USSR west of 100° East Longitude. Approximately 329 surface samples were used to map arboreal pollen, and 212 samples for herb pollen. We are presently revising the maps of forest regions with the addition of samples containing only arboreal pollen (AP) data.

Figure 6 gives examples of these maps. High values of pine pollen (above 20%) are found in the mixed and conifer forests (6a). Birch pollen attains highest percentages to the north of pine (6b). Fir pollen exceeds 20% only in the Kola Peninsula, to the north of the pine belt (6c). High values of arboreal pollen (above 20%) are restricted to vegetation zones north of the steppe region (6d). In the steppe, semi-desert, and desert zones, herb pollen, such as Artemisia and Chenopodeaceae are dominant (6e). Deciduous arboreal pollen is restricted to the mixed forest zone (6f).

These preliminary maps show a good correspondence between major pollen types and vegetation zones (6g). The next step is to examine

Figure 5. SURFACE POLLEN SAMPLES, USSR (GENERALIZED)



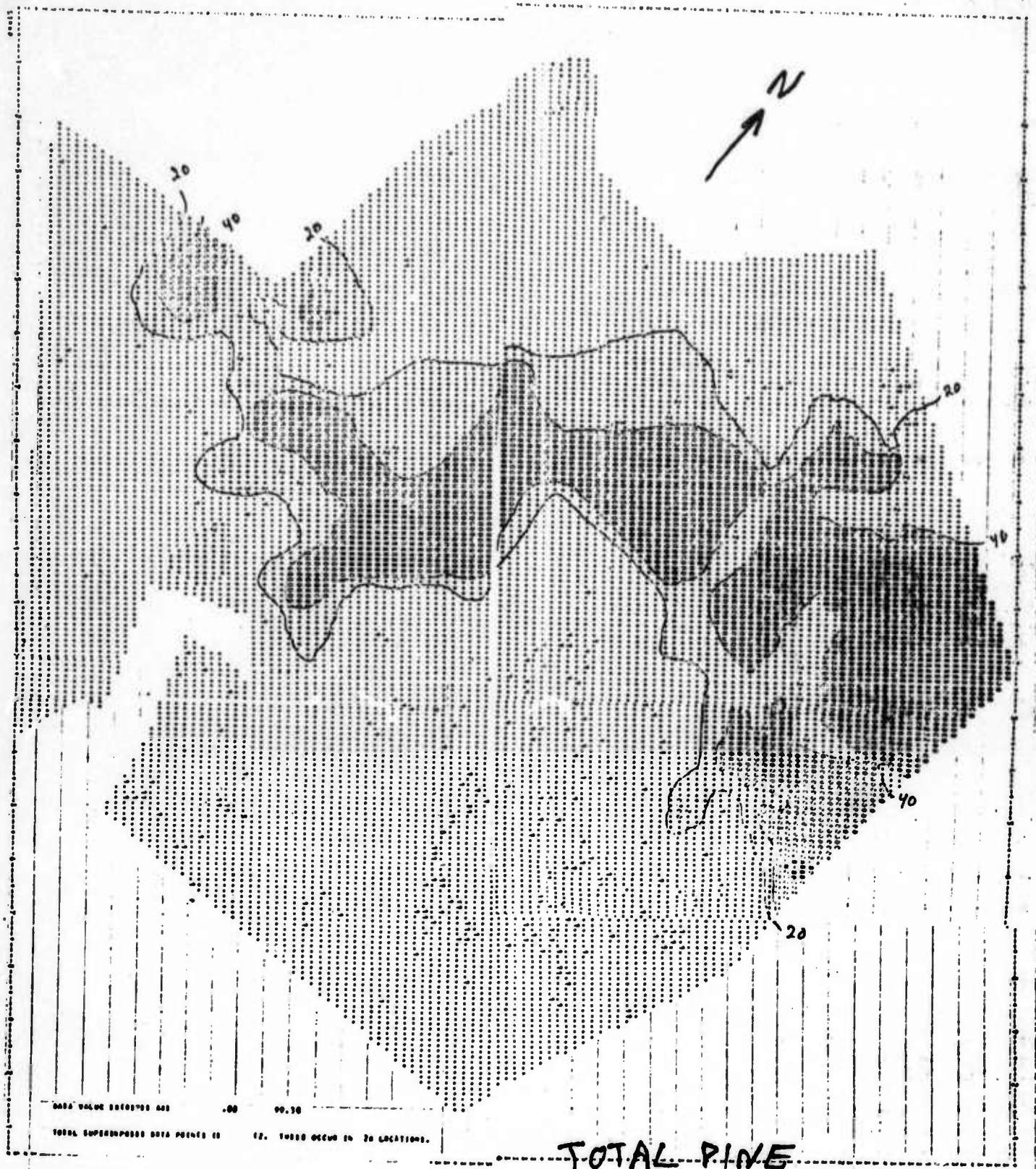


Figure 6a.

Figure 6b.

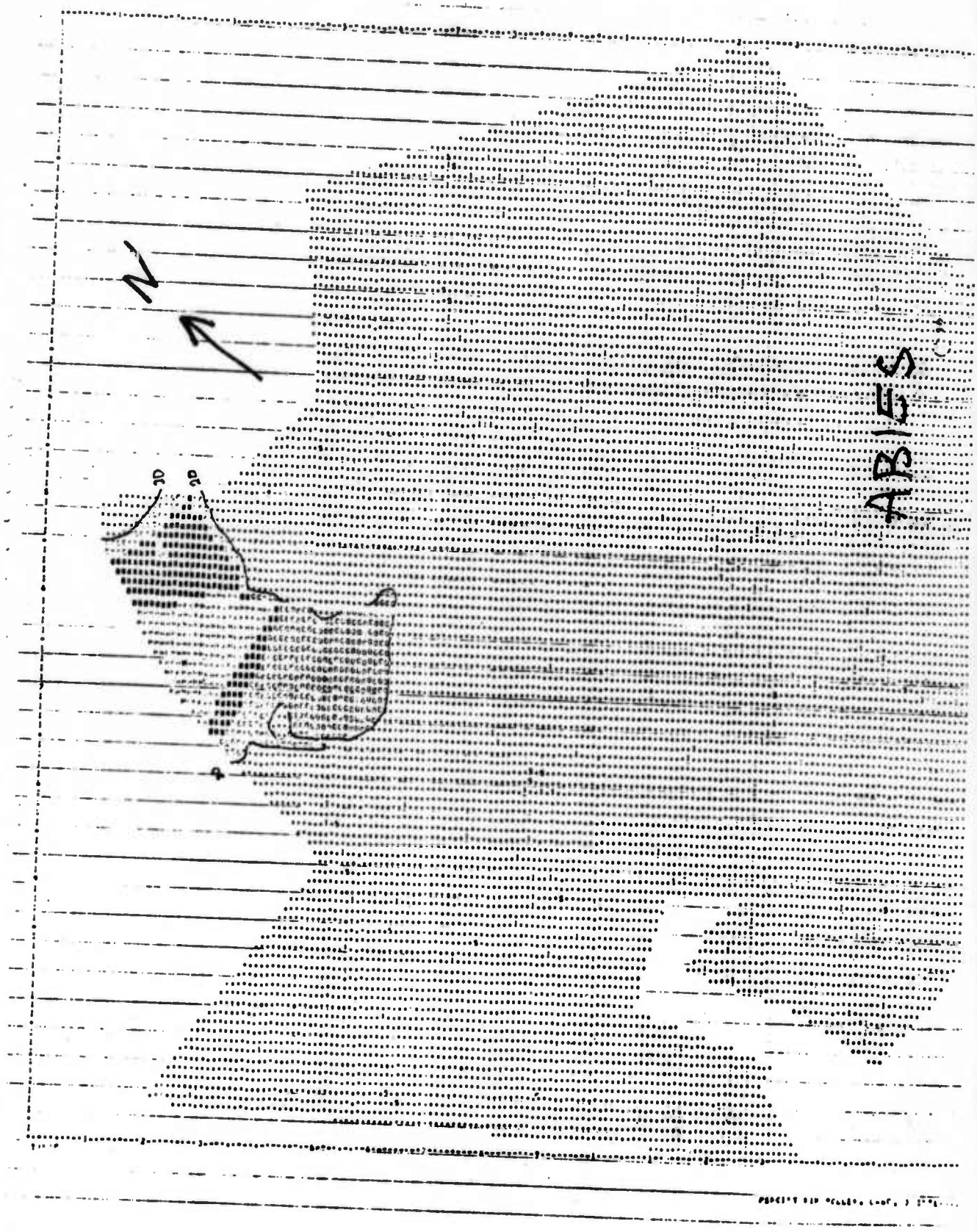


Figure 6c.

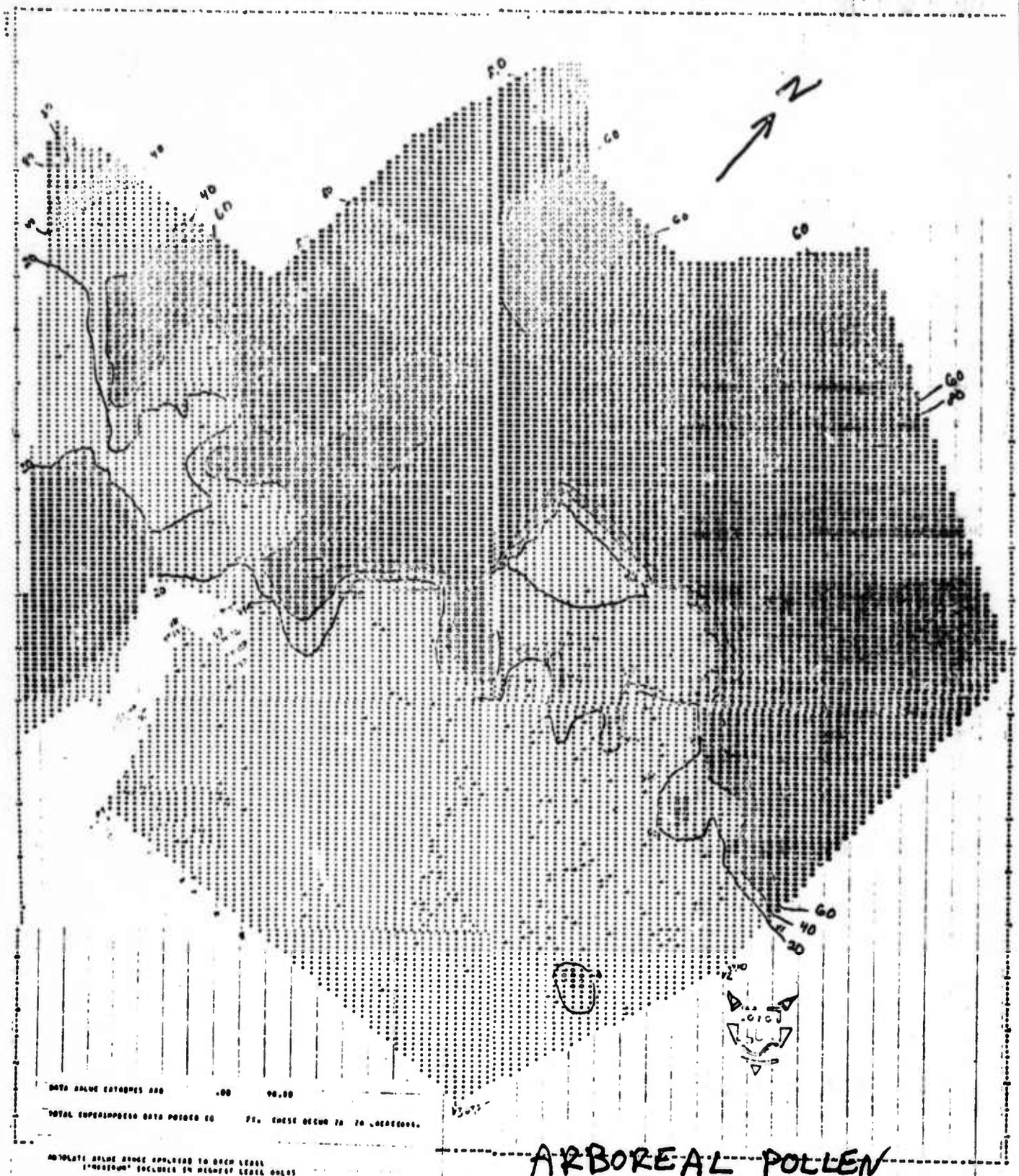


Figure 6d.

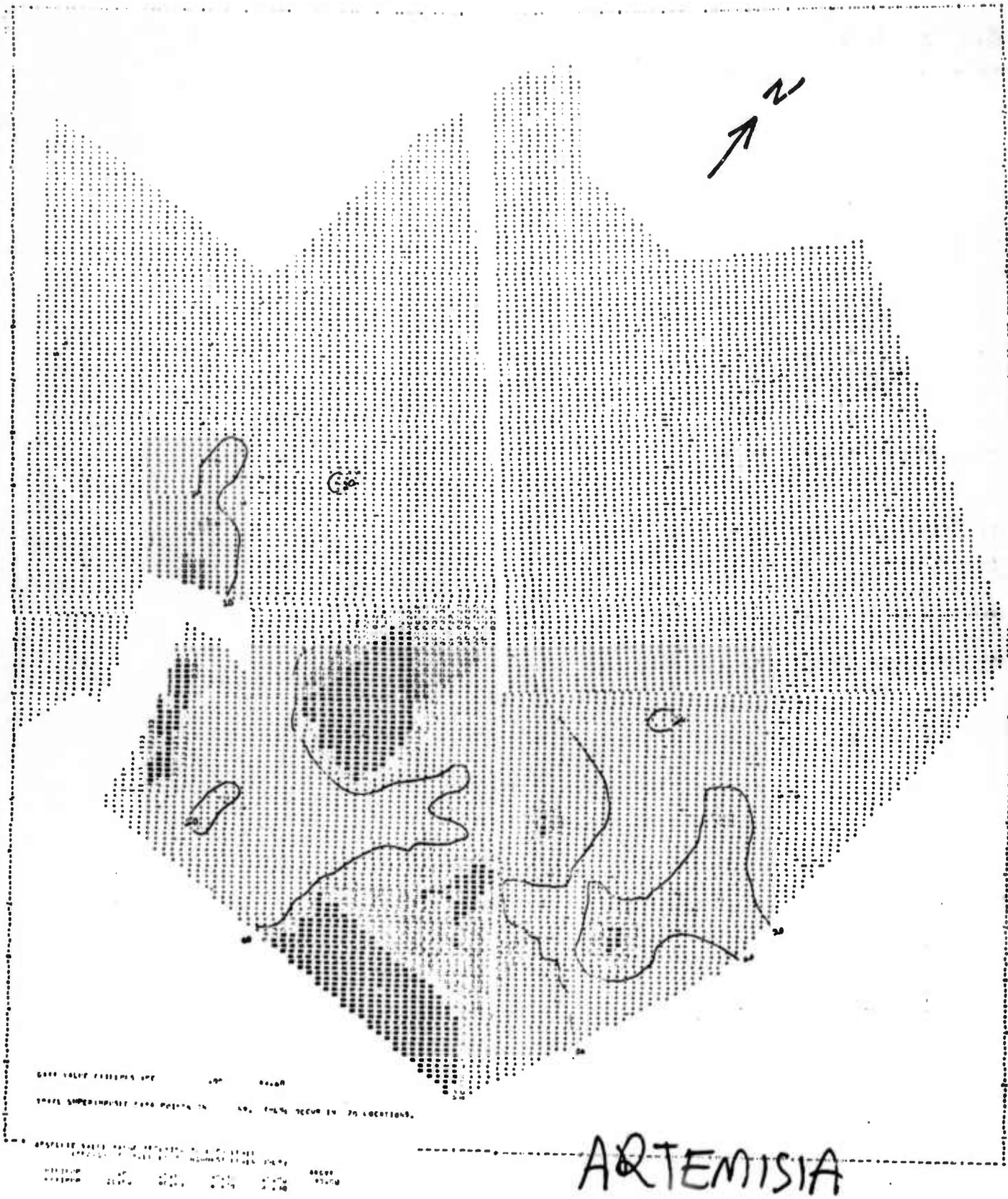


Figure 6e.

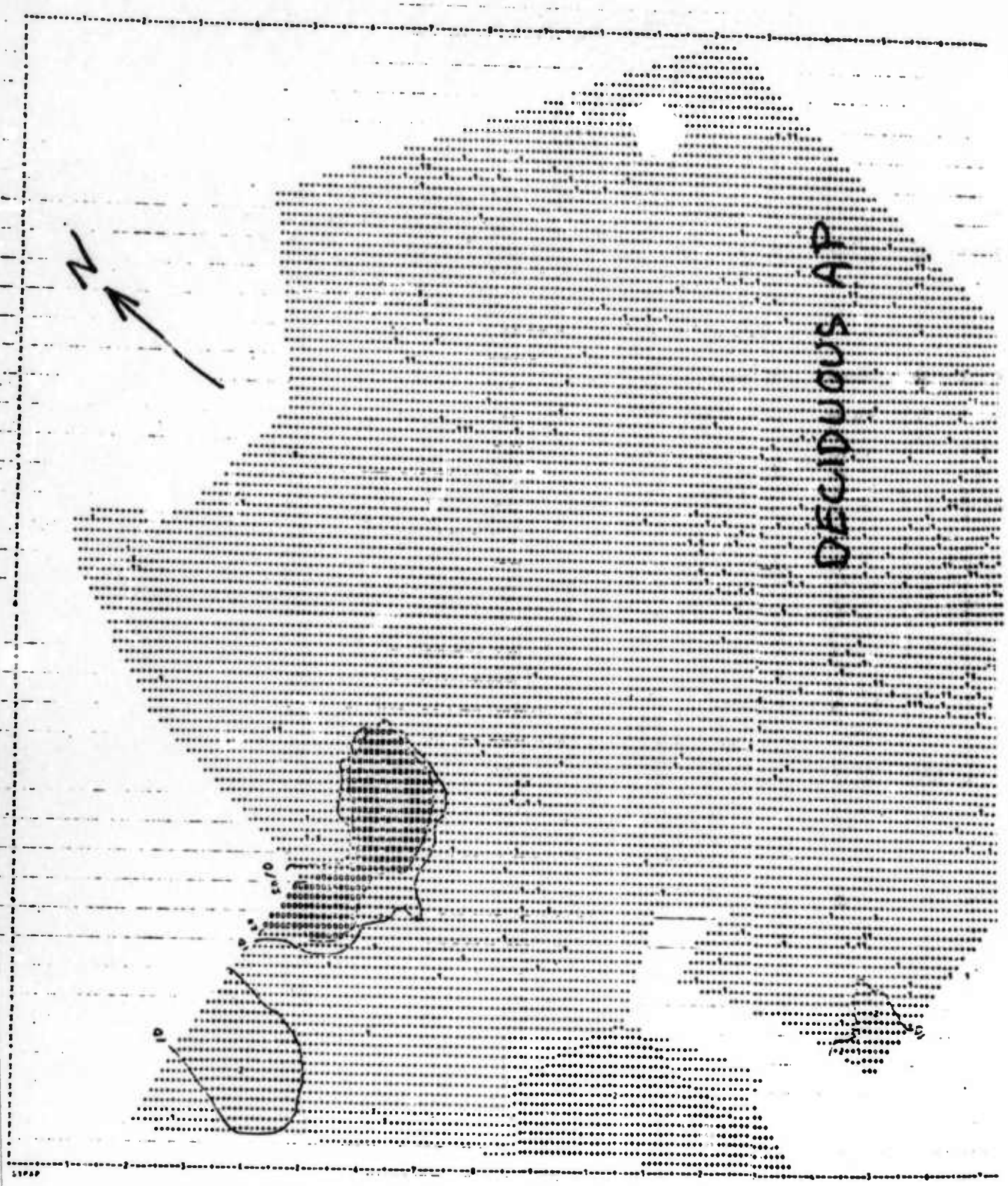


Figure 6f.

DECIDUOUS TREE POLLEN . 2- 33. 3 INTERVALS
DECIDUOUS SHRUB POLLEN • CARPINUS • BOP • ERI
QUERCUS • TILIA • ULMUS • ACER

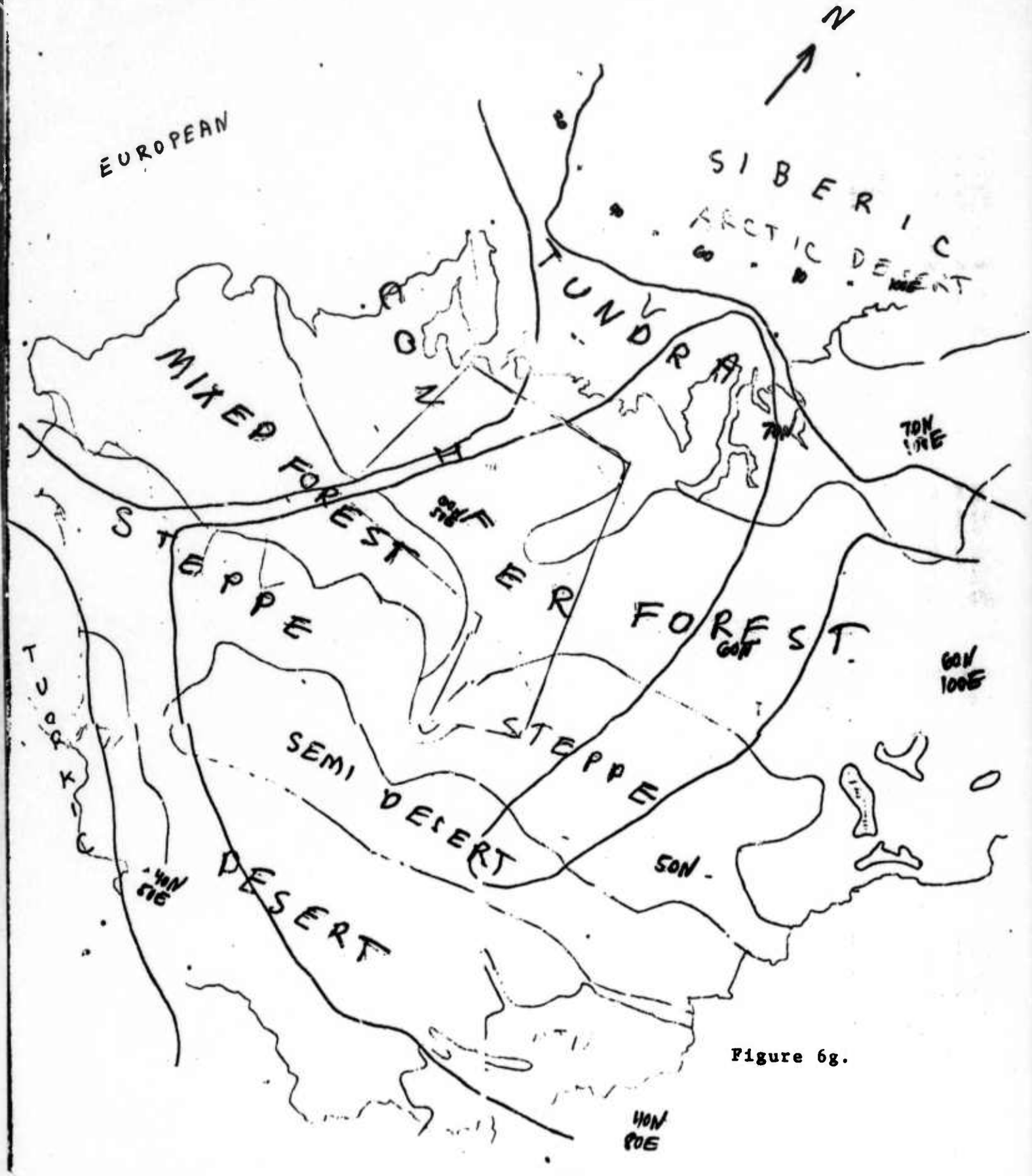

N
EUROPEAN
SIBERIC
ARCTIC DESERT
TUNDRA
MIXED FOREST
STEPPE
FOREST
STEPPE
SEMI DESERT
DESERT

Figure 6g.

the relationships between pollen percentages and climatic variables.

Upon completion of mapping of surface pollen and modern climatic data, we will make similar maps from fossil pollen data at intervals of 1,000 to 2,000 years for the post-glacial period. These fossil pollen maps will then be used to check numerical reconstructions of fossil pollen data.

Holocene pollen diagrams arealso abundant. Neishtadt (1957) used 155 pollen diagrams to reconstruct vegetation history for the USSR in the last 12,000 years (see figure 7). Many more pollen diagrams have subsequently appeared, and radiocarbon chronologies are fairly well established for the European USSR. Figure 8 shows the locations of 23 dated pollen diagrams in the Soviet Union.

The majority of surface samples and pollen diagrams are from the region west of 90° E, and the majority of C-14 dated diagrams are from the area west of 45° E. The area from European USSR to the Western Siberia lowland will thus be most fruitful for climatic reconstructions, although dated pollen diagrams and surface sample data are also available from northeastern Siberia, Sakhalin, and the Kamchatka Peninsula.

A recent reference by Grichuk (1973) indicates that very little has been done in the USSR to quantitatively reconstruct past climates from pollen data. We have found only one such reference for the Holocene (Grichuk, 1969). The attempt by Grichuk was based on the geographical extent of certain species, and is less sensitive than the multivariate statistical techniques which will be used in the present study.

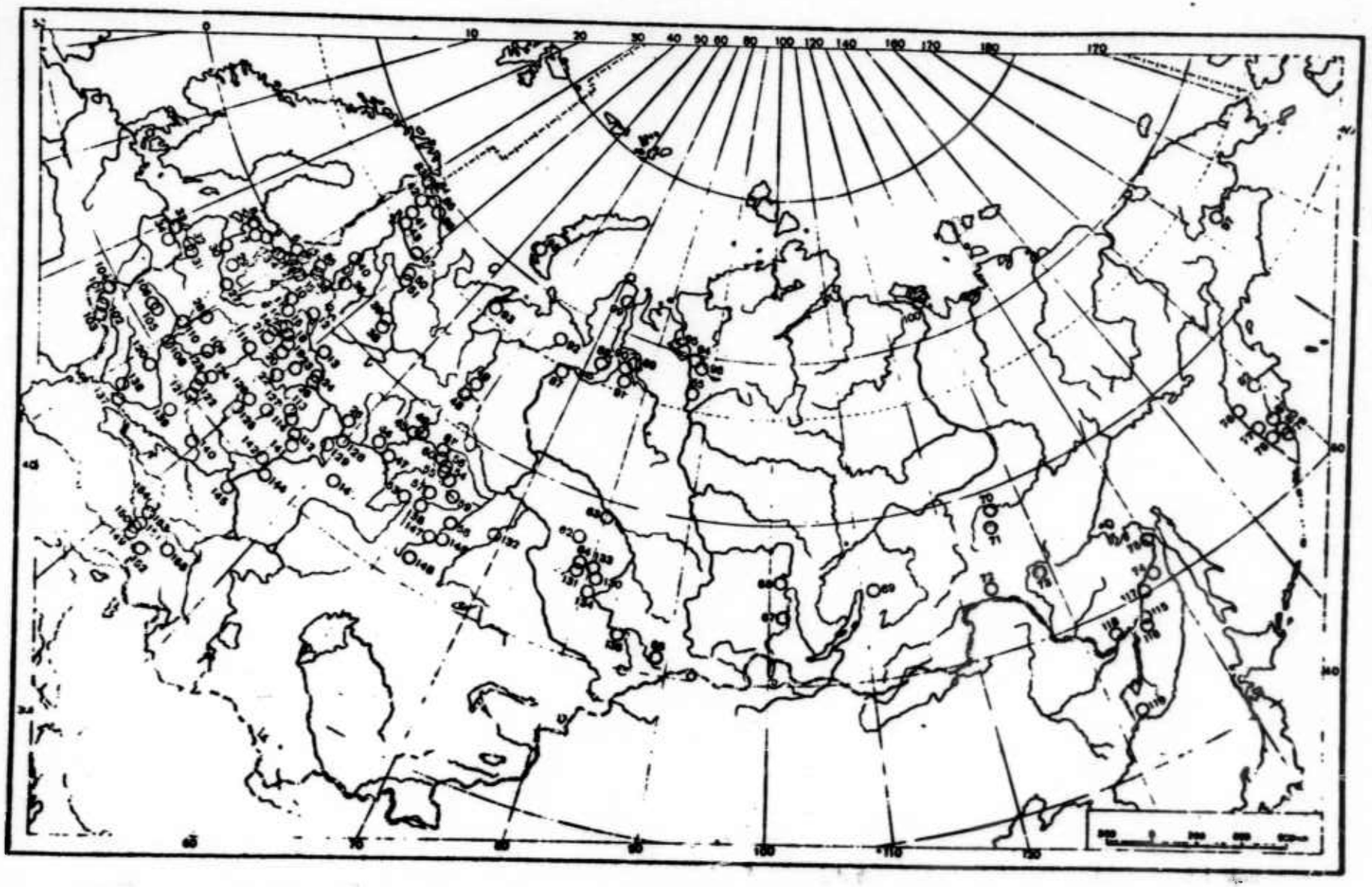


Figure 7. Location of 155 Holocene pollen profiles used by Neishtadt. (After Neishtadt, 1957, Fig.2)

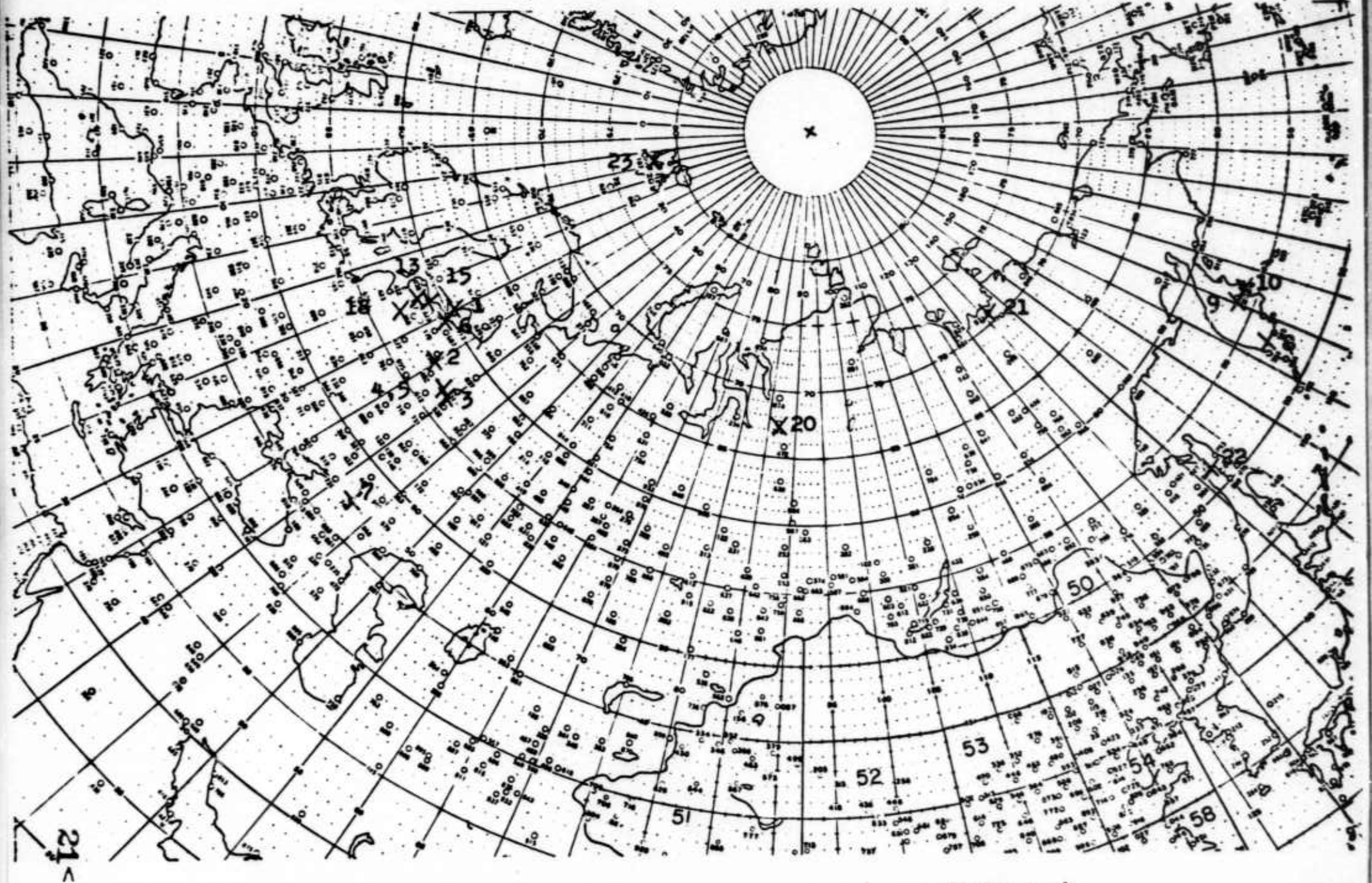


Figure 8. Location of Radiocarbon-Dated Pollen Diagrams in the U.S.S.R. (Holocene)

The present study, in conjunction with those currently in progress for Eastern North America (Webb, et al.; Swain, in preparation) will provide reconstructions of synoptic paleoclimatic patterns over a large segment of the Northern Hemisphere.

c) India (Bryson, Swain, Webb)

A set of calibration functions have been derived from the surface pollen data in Northwestern India and time series of temperature and rainfall have been reconstructed for cores from Kuckaranzar and Didwana (see preliminary report in Bryson, 1974, IES Report #27).

2.2 Pollen records (the last 1000-2000 years), A. Swain

The purpose of this research is to reconstruct the patterns of short-term climatic changes over the past 1000-2000 years by using quantitative techniques to calibrate pollen assemblages, varve measurements, and charcoal influx in terms of climate from annually laminated (varved) sediments from lakes in northeastern North America. Because precise dating is possible from varved lakes, the climatic reconstructions from varve thicknesses and pollen counts were used independently to verify climatic reconstructions from tree rings as well as extending the climatic record in areas where tree-ring chronologies are relatively short (less than 300 years) or are insensitive to climatic variability.

Status

Cores of varved lake sediment were collected from lakes in Wisconsin and during 1974, five other varved lakes were located and sampled in eastern United States. A total of about 30 varved lakes have been found in northeastern North America. (Figure 9) of which only about 15 are adequately varved for dating purposes. Lakes have been located in Washington, Idaho, Montana, and Manitoba that may have varved sediments. These will be sampled in September of 1975. This network provides a basis from which synoptic patterns of short-term changes of climate can be viewed.

Pollen and charcoal counts from a series of samples of ten years each over a period of 1000 years have been completed from three lakes with varved sediments - 70 samples from Lake of the Clouds (northeastern Minnesota, Swain, 1973), 40 and 30 samples from Hell's Kitchen and Dudley Lake respectively (both in north central Wisconsin). The pollen diagrams are shown in Figures 10, 11 and 12. In addition, the pollen and charcoal record at Hell's Kitchen Lake has been extended to cover the period from 1000 to 2000 years ago (Figure 10a) to tie in with Denton's studies (1973) on the activity of mountain glaciers over the past 2000 years.

A climatic interpretation based on the results of pollen and charcoal analysis from these three lakes suggests a "Little Ice Age" event with an increase in precipitation or a decrease in temperature or both for the period 1450 to 1850 A.D. An earlier cooler or wetter

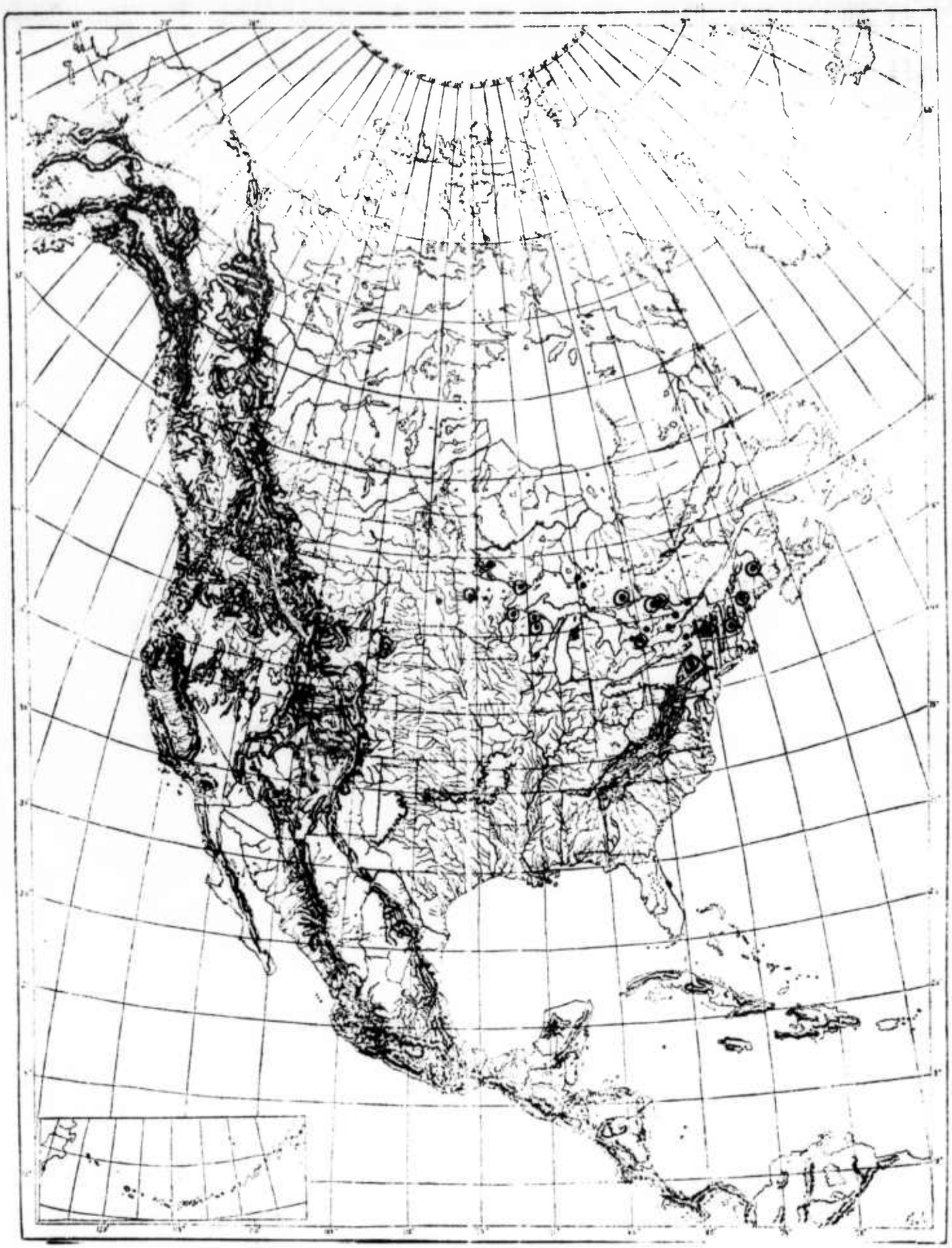


Figure 9 . Locations of lakes with varved sediments. Circled points indicate lakes with varves that are adequate for dating purposes.

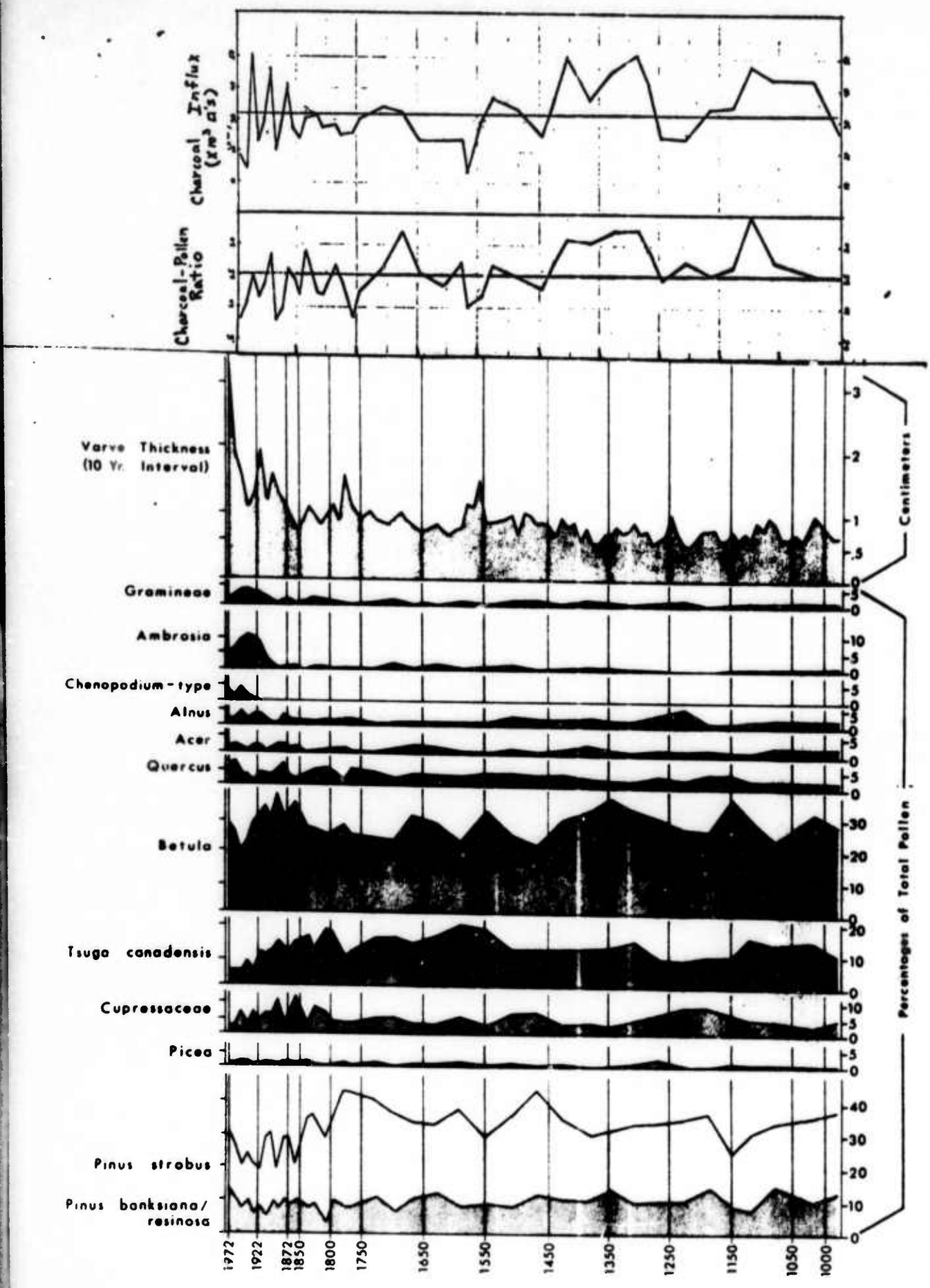


Figure 10. A 1000-year pollen and charcoal diagram from Hell's Kitchen Lake. The data points for each curve are based on 10-year averages. Note that the time scale for the charcoal curves is not identical to that for the pollen curves.

HELL'S KITCHEN LAKE
VILAS COUNTY, WISCONSIN

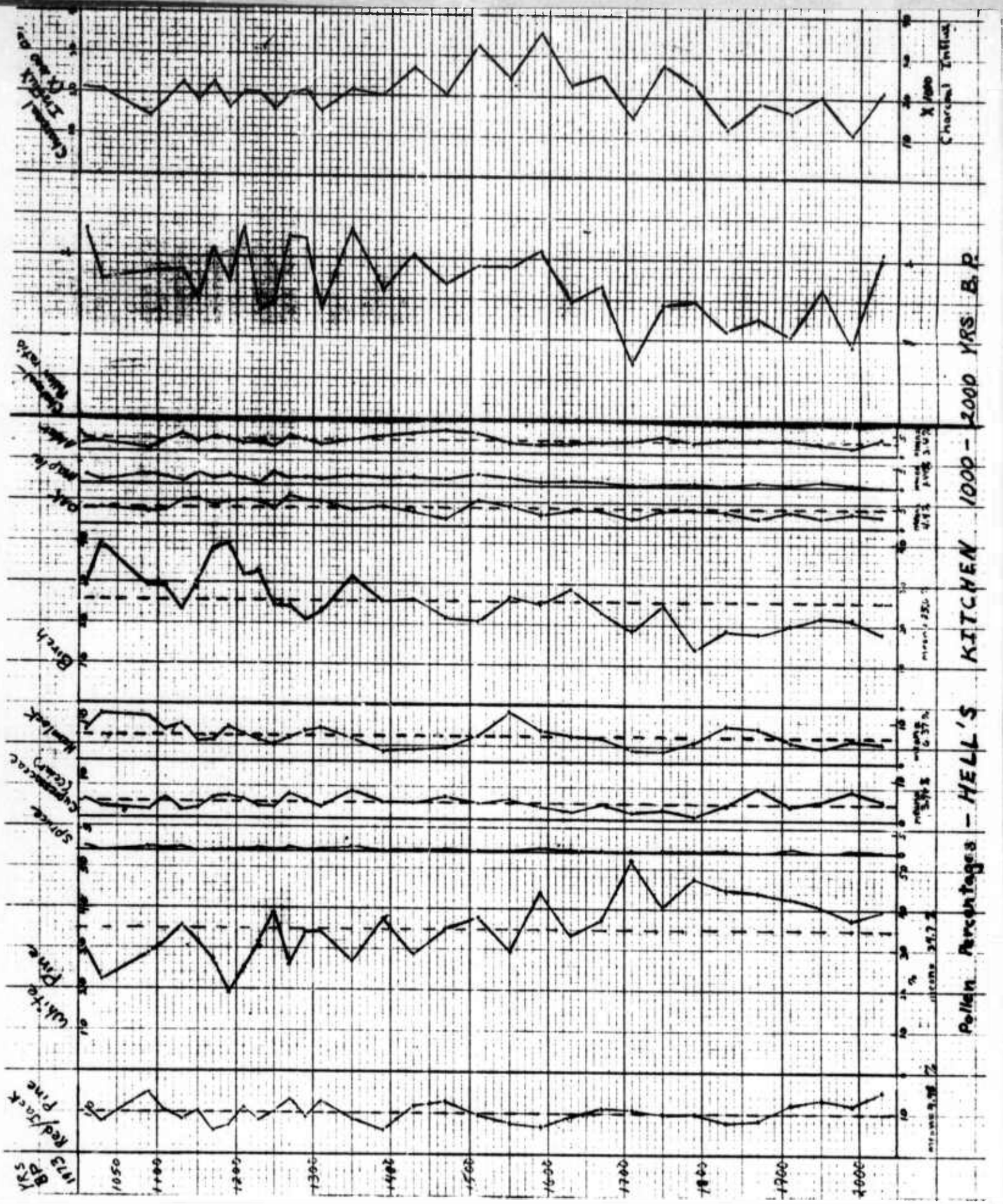


Figure 10a. Pollen and charcoal diagram from Hell's Kitchen Lake. This is a continuation of Fig. 2, but the scales are not the same. The dashed lines through several of the pollen profiles represent the mean for the 1000-2000-year interval.

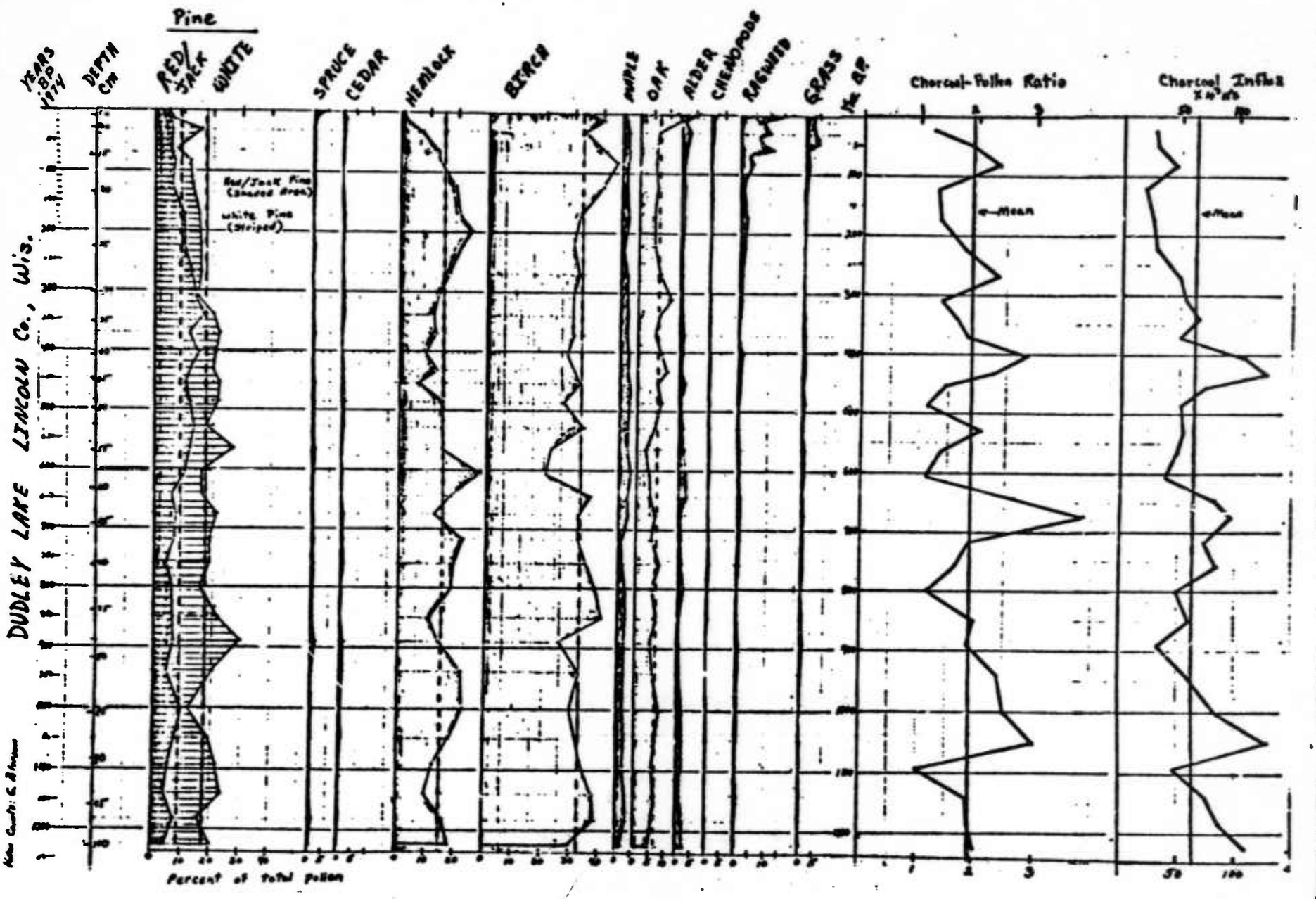


Figure 11. A preliminary draft of a 1200-year pollen and charcoal diagram from Dudley Lake. The dashed lines through several of the pollen curves represent the means for those pollen types.

LAKE OF THE CLOUDS, MINNESOTA

A. M. Swain 1973

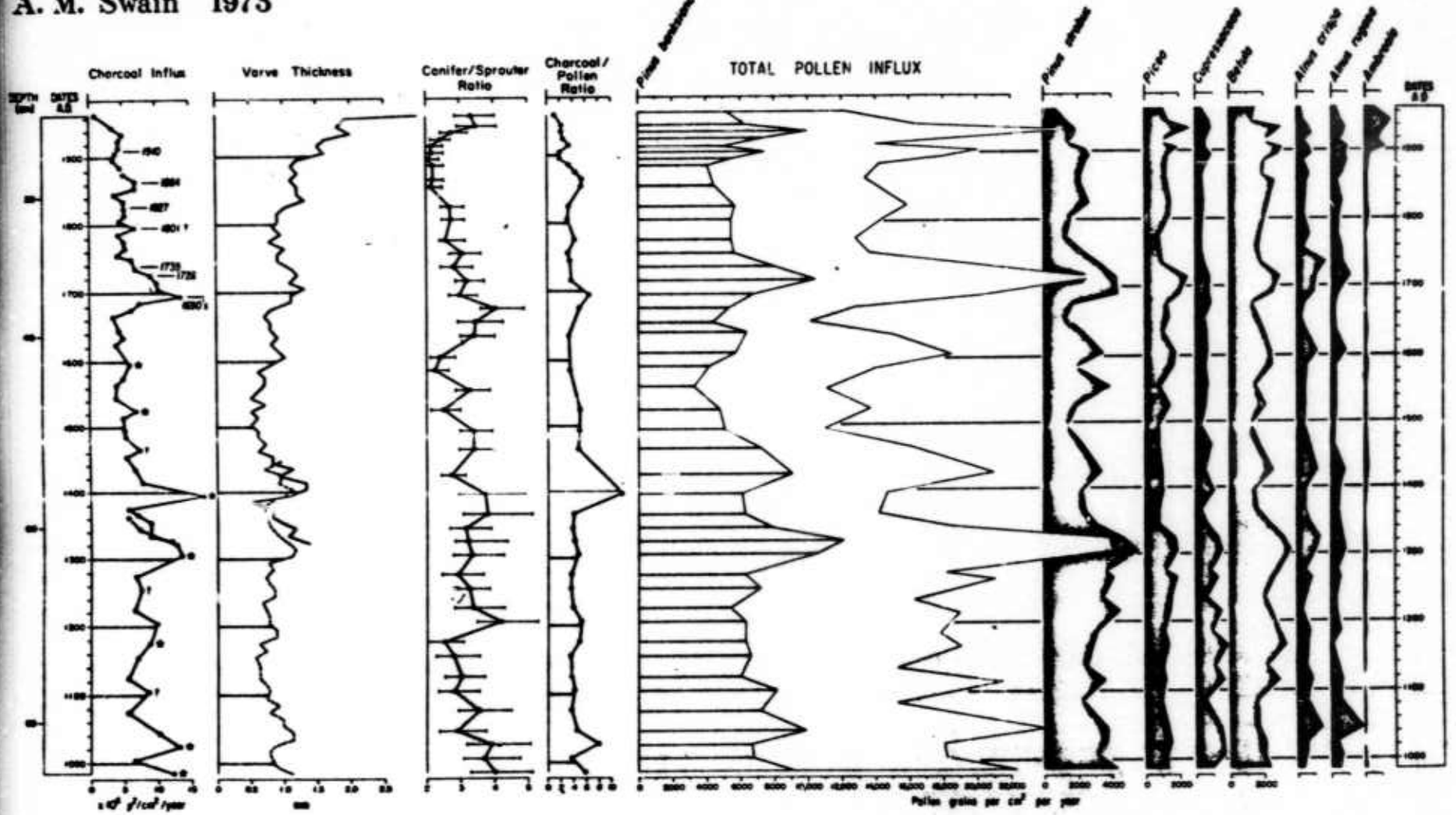


Figure 12. Charcoal and pollen influx diagram for the last 1000 years at Lake of the Clouds. The data points for each curve are based on 10-year averages.

period is indicated at Hell's Kitchen between 2000 and 1600 years B.P. This result precedes a minor glacial advance in Alaska that occurred between 1250 and 1050 years B.P. (Denton and Karlén, 1973). The pollen diagrams (Figs. 10,11,12) show a decrease in the percentages of the pioneer species of jack/red pine (Pinus banksiana and P. resinos and particularly birch (Betula papyrifera) which require periodic fires for adequate reproduction and an increase in the longer lived species such as hemlock (Tsuga canadensis) and spruce (Picea, sp.) which can reproduce in the absence of fire. A relative increase in moisture would result in a decreased frequency of fire and thus favor spruce at Lake of the Clouds and hemlock at Hell's Kitchen Lake and Dudley Lake. Increases of white pine (P. strobus) are shown at Hell's Kitchen between 2000 and 1600 Y.B.P. and 1450-1850 A.D., but are only temporary during the 1450-1850 A.D. interval since it is later replaced by hemlock. White pine also requires fire for good reproduction but not at a frequency as short as that for jack pine or birch. Decreased values of charcoal influx and of charcoal/pollen ratios during the intervals of 1450 to 1850 A.D. and of 0 A.D. to 300 A.D. confirm the above interpretation of a relative increase in moisture.

The beginning of agriculture in the region is marked by the increased values of ragweed (Ambrosia), grass (Gramineae), and chenopods (Chenopodium Type) during the past 70 years at the three sites. The low values of white pine and hemlock for about the last 60 years at Hell's Kitchen are probably due to logging adjacent to the lake.

Because the independent results from these three lakes agree, this strongly indicates that pollen and charcoal analysis from varved lake-sediment provides a sufficiently sensitive proxy record of short-term climatic changes. These results also provide the first detailed record of a "Little Ice Age" event for midwestern United State

Climatic reconstruction from two lake cores (J. Pollack)

The pollen surface sample and climatic data arrays previously obtained for the Upper Midwest were utilized to make climatic reconstructions from the Lake of the Clouds and the Hell's Kitchen Lake pollen cores for the past thousand years, by John Pollack. Canonical correlation analysis was used to obtain the calibration functions between pollen and climate that allowed the reconstruction of climatic variables from each pollen sample (Webb and Bryson, 1972).

The temperature reconstructions obtained indicated that growing season temperatures within the last 450 years were highest in the last 75 years and from the mid-1700's to the early 1800's. There was a very cool period in the mid-1800's, and the coldest period in the entire record was experienced from about 1550 to 1725. The Little Ice Age episode, with a prominent temperature peak at 1475, followed by an abrupt decline to persistently lower temperatures, is clearly indicated. A temperature minimum occurred around 1400, with a minor maximum at about 1300. Prior to 1300, temperatures were relatively warm, with no important changes.

The growing season precipitation reconstructions showed a recent dry period preceded by a moist period lasting through the 19th century. Generally dry conditions prevailed between 1400 and 1800, and moist conditions from 1150 to 1350. The dry period was somewhat longer in the reconstructions at Lake of the Clouds than that a Hell's Kitchen Lake, but was interrupted by a 125-year moist period around 1575. The earliest part of the reconstruction, from 975 to 1100 was characterized by quite dry conditions culminating at about 1075.

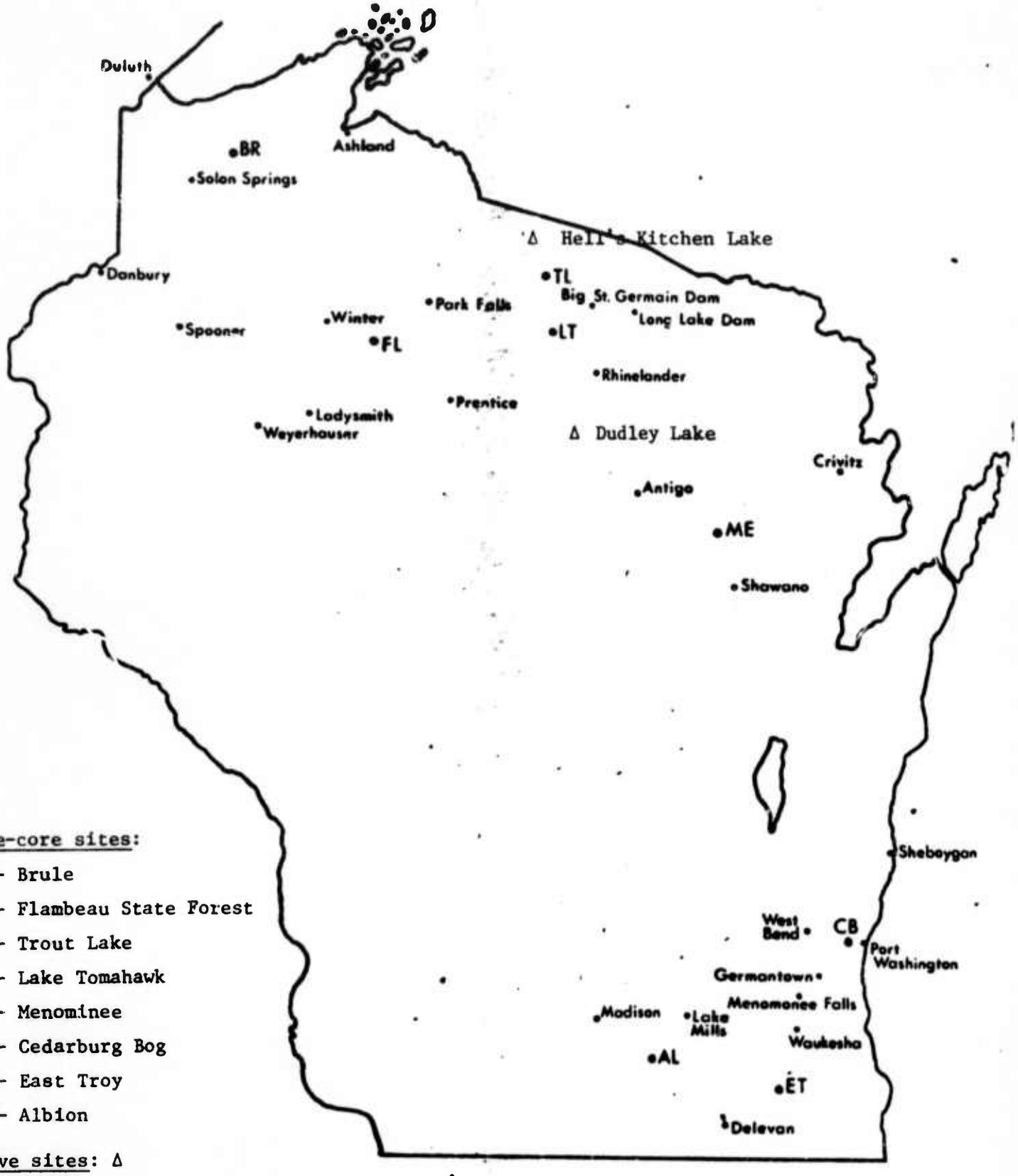
2.3 Tree core records (W. Wendland)

Tree cores have been obtained from several sites in northern United States. The sites were chosen to be near lakes which have been cored and found to contain varves (see Swain, this report). The cores are useful, not for their long length, but because they will provide an independent climatic reconstruction for the same general region in which the varved lakes are located. The much longer climatic record of the varved lakes (10^3 years) will be calibrated with the climatic reconstructions obtained from tree cores (10^2 years), as well as the (now) standard calibration in terms of surface pollen-climate relationships.

Collection and processing of tree cores

Over 200 cores have been obtained from the eastern and northern boundaries of Wisconsin (see Figure 13). The site chronologies

Figure 13. Tree-core and Varve Sites in Wisconsin.



Tree-core sites:

BR - Brule

FL - Flambeau State Forest

TL - Trout Lake

LT - Lake Tomahawk

ME - Menominee

CB - Cedarburg Bog

ET - East Troy

AL - Albion

Varve sites: Δ

Climatic Stations:

Place names given.

typically are about 200 years long, with the longest (Menominee County) being about 280 years. Master chronologies (average annual growth for all trees of each site) have been prepared for each site and a preliminary relationship to climate has been obtained. At present, a statistical calibration function is being prepared which will convert past growth information into climatic information. The calibration function is based upon the relationship between climate and growth from the recent decades when both types of data are available.

Tree cores have also been obtained from Algonquin Provincial Park, Ontario; four sites from Pennsylvania to Maine; and from several log buildings constructed in the mid-1850's in Wisconsin. Master chronologies are being prepared for the sites in Canada and the eastern United States. These will be used in a manner similar to that for the Wisconsin trees, i.e., to calibrate varve cores from nearby lakes. The cores from the nineteenth century Wisconsin buildings are up to 150 years long and therefore will extend the record back to about A.D. 1700 for the southern and southwestern part of Wisconsin. These cores have just been obtained, therefore no analyses have been completed.

Prof. Patrick Munson of the University of Indiana worked under a subcontract from us, to develop tree chronologies from southern Illinois and southern Indiana. He and one assistant sampled several sites and have provided us with increment measurements from about

40 trees from two of the sites thus far. They intend to continue work on the cores from those sites where trees are at least 150 years old and cross-date with each other. However, cross-dating has been a problem at several of the sites.

Eight trees from Horseshoe Lake, in extreme southern Illinois, provide a chronology in excess of 350 years. Some cores of this site are from dead, buried trees, but cross dated with living trees. Preservation of dead, buried cypress is very good, therefore it is hoped that the chronology will be further extended with additional dead material. The master chronology is being prepared at the present time. The relationship between growth of these trees (bald cypress, Tasodium distichum) will be investigated in the near future. Munson has found several years which are signature years, i.e., either very narrow or wide rings in most cores. indicating close cross-dating.

Collection of climatic records (E.W. Wahl and J. McQueeney)

Continuous climatic data (temperature and precipitation) have been collected and averaged for several stations about each of the tree sites. They typically represent records of about 80 years, with the data expressed as deviations from the 1931-1960 mean. This method establishes an areal deviation from the mean.

Development of tree ring analysis computer programs (Wendland & Widder,

A program to identify missing or false rings in tree cores was developed and has been accepted for publication in the Tree Ring Bulletin. In addition, a program has been written to produce a skeletal plot of a tree's growth. The program calculates the mean growth for overlapping five-year intervals, and expresses each year's growth as a deviation from the mean in standard deviation units. We are currently testing the program in the laboratory.

2.4 Collection of historical climatic records (Wendland & Woodworth)

A data bank of references of early accounts of weather and climate was begun under this grant. Assemblages of this sort are useful and necessary for verification of climatic reconstructions based on proxy records. The data bank includes over 670 entries. These are now punched on cards and can be sorted by time or area.

A paper is in preparation analyzing climatic changes as noted in climatic journals from Russian Alaska (early 1800's) compared to the present. This paper will be completed within the next year.

A short note has been prepared announcing the availability of the data bank, and will be submitted to several appropriate journals, soliciting additional information sources and offering data bank information to interested parties. Prof. H.H. Lamb has a long list of references and is interested in establishing a punch card retrieval system. We have shown him our format for information and

expect that a similar format will be devised so that information will be compatable with either system. A copy of "Data Bank of Early Climatological Sources" is included in this report as Appendix A.

LITERATURE CITED

Boyko, Maria (1973). European Impact on the Vegetation Around Crawford Lake in Southern Ontario. M.S. Thesis, Dept. of Botany, Univ. of Toronto.

Birks, H.J.B., T. Webb III and A.A. Berti (in press). Numerical Analysis of Surface Pollen Samples from Central Canada: A comparison of Methods. Review of Palaeobotany and Palynology.

Bryson, R.A. (1974). World Climate and World Food Systems III: The Lessons of Climatic History. IES Report 27, Institute for Environmental Studies, Univ. Of Wisconsin-Madison.

Davis, R.B. and T. Webb III (in press). The Contemporary Distribution of Pollen in Eastern North America: a Comparison with the Vegetation. Quaternary Research 5.

Denton, G. and Karlén (1973). Holocene Climatic Variations-Their Pattern and Possible Cause. Quaternary Research, 3(2): 155-205.

Grichuk, V.P. (1969). Opyt rekonstrucktsii nekotorykh elementov klimata severnogo polushariia v Atlanticheskii period golotsena. In M.I. Neishtadt, ed. Golotsen. K VIII kongressu INQUA, Paris, 1969. Moscow, Izd-vo Nauka, pp. 41-57.

Grichuk, V.P. (1973). Paleoekologicheskie rekonstruktsii po palinologicheskim dannym. In Akademiia nauk SSSR. Institut geografii. Paleogeografiia Evropy v pozdenm Pleistotsene. K IX Kongressu Mezhdunarodnoi Assoitsiatsii po izucheniiu chetvertichnogo perioda, New Zealand, 1973. Moscow, 1973, pp. 230-232.

Neishtadt, M.I. (1957). Istoriia lesov i paleogeografiia SSSR v golotsene. Moscow, IZD-vo akademii nauk SSSR. Institut geografii.

Swain, Albert M. (1973). A History of Fire and Vegetation in Northeastern Minnesota as Recorded in Lake Sediments. Quaternary Research 3(3): 383-396.

Webb, T. III and R.A. Bryson (1972). Late- and Postglacial Change in the Northern Midwest, U.S.A.: Quantitative Estimates Derived from Fossil Pollen Spectra by Multivariate Statistical Analysis. Quaternary Research 2: 70-115.

Webb, T. III and J.H. McAndrews (in press). Corresponding Patterns of Contemporary Pollen and Vegetation in Central North America. Geological Society of America Memoir, No. 145.

APPENDIX A

DATA BANK OF EARLY CLIMATOLOGICAL SOURCES

The Center for Climatic Research at the University of Wisconsin-Madison and the Laboratory of Tree-Ring Research, University of Arizona-Tucson, have established a collection of climatic references for the purpose of studying climate and climatic changes using historical records. These data have been gathered from published and manuscript sources--narratives, logbooks, early scientific journals, etc. A reference may be for a single event (e.g., observations by Drake off the west coast of California, June, 1579), a series of meteorological observations (e.g., daily observations in Emay, China, Oct. 1698 - Jan. 1699, of pressure and wind direction), or a general description of the climate (e.g., Sooloo, Philippines, ca. 1700). Also included are some bibliographic source references for early climatic data.

This data bank may serve a variety of needs, e.g., extend the climatological record back in time and in space, provide quantitative records against which alternate environmental information (trees, pollen, etc.) may be calibrated, and to provide an environmental "backdrop" for historical events.

The references are organized by location (latitude and longitude, country, and in some cases, smaller scale political divisions) and by time. The information has been punched on computer cards and may be extracted by location and/or time (years before 1950) to

secure a list of the appropriate references. Information contained in the reference includes the climatic parameters, and the frequency and length of the observations.

The collection currently contains about 700 references, mostly from non-climatological journals. At this time (5/75) the temporal and spatial distribution of references is:

Distribution by time:

Prior to 1600 AD	60 entries
1600's	40 "
1700's	201 "
1800's	354 "
1900's	20 "

Distribution by location:

Africa	67 entries
Antarctica	1 "
Asia	57 "
Australia	8 "
Europe	199 "
North America	216 "
South America	3 "
Ocean areas	114 "
Worldwide	10 "

We invite inquiries of the catalog and will send a listing for specific requests, i.e., latitude, longitude and time (given in years before 1950 for either one time, or a period with a beginning and ending date stated).

To fully develop this reference clearing house, we invite and encourage additions to the present listing. To submit information, please include location of observation, time and extent of data, as well as a complete bibliographic reference. We suggest also listing the library where reference is located. Please address inquiries to:

Center for Climatic Research
Attention: DATA BANK
1225 W. Dayton St.
Madison, Wisconsin 53706

The collection and organization of the data bank was in part supported by the Laboratory of Tree-Ring Research, Univ. of Arizona-Tucson, and the Center for Climatic Research, Univ. of Wisconsin-Madison (ARPA grant, Contract No. F44620-75-C-0005 and AFOSR-72-2407).

MANUSCRIPTS OR RECENT PUBLICATIONS SUPPORTED, PARTIALLY SUPPORTED OR OTHERWISE RELATED TO THIS GRANT.

Bender, Margaret M., Reid A. Bryson and David A. Baerreis (1975). University of Wisconsin Radiocarbon Dates XII, Radiocarbon 17(1): 121-134.

Bender, Margaret M., and Clanton C. Black, Jr. (1975). $^{13}C/^{12}C$ Ratios in Marine Organisms from the Great Barrier Reef, Australia, Australian Journal of Physiology, (in press).

Bernabo, J. Christopher and T. Webb III (1974). Cartographic Analysis of the Changing Time-Space patterns in the Holocene Pollen Record of Northeastern North America. Abstracts, AMQUA 3rd Biennial Meeting, Univ. of wisconsin-Madison, 30 July - 1 Aug. 1974, pp. 103-104.

Bernabo, J.C. and Webb, T. III (1976). Maps of the Changing Time-Space Patterns in Holocene Pollen Records from Northeastern North America, Quaternary Research (in press).

Blasing, T.J. (1975). Methods for Analyzing Climatic Variations in the North Pacific Sector and Western North America for the Last Few Centuries, Ph.D. Dissertation, Dept. of Meteor., Univ. of Wisconsin-Madison.

Bryson, R.A. (1974). World Climate and World Food Systems III: The Lessons of Climatic History, IES Report No. 27, 17 pp.

Bryson, R.A. (1974). On the Analysis of Pollen-Climate Canonical Transfer Functions, Quaternary Research 4, 162-174.

Chu, Pao S. (1974). Reconstruction of the Climatic Fluctuations over the Ohio Area, Masters Thesis, Dept. Of Meteorology, Univ. of Wisconsin-Madison.

Davis, R.B. and T. Webb III (1973). Corresponding Patterns of Pollen and Vegetation in Eastern North America (Abstract), INQUA Conference, Christchurch, New Zealand.

Davis, R.B. and T. Webb III (1975). The Contemporary Distribution of Pollen in Eastern North America: A Comparison with the Vegetation. Quaternary Research, 5 (in press).

Kutzbach, J.E. and R.A. Bryson (1974). Variance Spectrum of Holocene Climatic Fluctuations in the North Atlantic Sector, Journal of Atmospheric Sciences, 31(8): 1958-1963.

Nolte, F. Climatic History of York Factory, Canada, During the Last Two and One-half Centuries (in preparation).

Peterson, G.M. (1974). Translation - "An Attempt to Reconstruct Certain Elements of the Climate of the Northern Hemisphere in the Atlantic Period of the Holocene," by V.P. Grichuk, 1969, Opyt rekonstruktsii nekotorykh elementov klimata severnogo polushariia v Atlanticheskii period golotsena, In M.I. Neishtadt, ed. Golotsen.K VIII kongressu INQUA, Paris.

Peterson, G.M. (1975). Translation - "Transcontinental Correlation of Stages in the History of Vegetation and Climate of Northern Eurasia in the Holocene," by N.A. KHotinskii, 1973, Transkontinental'naia korreliatsiia etapov istorii rastitel' nosti i klimata severnoi Evrazii v Golotsene. In M.I. Neishtadt, ed., Problemy palinologii. Trudy III mezhdunarodnoi palinologicheskoi konferestsii, Moscow, Nauka, pp. 116-123.

Peterson, G.M. (1975). Translation - "Concentration of Radiocarbon in Tree-rings 1564-1583, 1593-1615, 1688-1712." by G.E. Kocharov, et al., 1974, In Vsesoiuznoe soveshchanie po probleme Astrofizicheskie iavleniia i radiouglerod, fifth, Tbilisi, 1973, Trudy. Tbiliso, izd-vo. Tbilisskogo un-ta, pp. 47-60.

Peterson, G.M. (1975) Bibliography of Surface Pollen Spectra from the USSR, Appendix C in Proposal to the National Science Foundation in support of COHMAP...subm April, 1975.

Peterson, G.M. (1975). Pollen Analysis of Cave and Surface Sediments in Central Kentucky, (subm. for publ.).

Pollack, John A. (in preparation). A 1000-year Climatic Reconstruction for Northern Wisconsin Using Canonical Correlation Analysis.

Swain, A.M. (1972). A Fire History of the Boundary Waters Canoe Areas as Recorded in Lake Sediment. Naturalist 23(3) and (4): 24-31, Autumn and Winter.

Swain, A.M. (1973). A History of Fire and Vegetation in Northeastern Minnesota as Recorded in Lake Sediments, Quaternary Research 3(3): 383-396.

Swain, A.M. (1974). The Potential for Detailed Climatic Reconstructions in Northeastern North America from Varve Thicknesses and from Varve-dated Pollen Diagrams, Abstracts, AMQUA 3rd Biennial Meeting, Univ. of Wisconsin-Madison, 30 July 1974 - 1 Aug. 1974, p. 8.

Swain, A.M. (in preparation). Thousand Year Pollen Record of Hell's Kitchen Lake - an Annually Laminated Lake in North-central Wisconsin,

Swain, A,M. and R.A. Bryson (in preparation). Paleoclimatic Reconstructions from Northwestern India.

Veneman, Peter L.M. Jr., A.M. Swain and F.C. Hole (1974). Soils and Varved Sediments of the Lake Emrick Drainage Basin in Marquette County, Central Wisconsin. In Late Quaternary Environments of Wisconsin, (J.C. Knox and D.M. Mickelson, eds.) A Field Guide prepared for AMQUA, 3rd Biennial Meeting, Univ. of Wisconsin-Madison, pp. 233-243.

Webb, Thompson, III and J.H. McAndrews (1973). Maps of the Modern Pollen from Central North America (abstract), INQUA Conference, Christchurch, New Zealand.

Webb, T. III, and C. Bernabo (1974). Palynological Evidence of Ecotonal Migrations in Eastern North America, Abstracts, AMQUA, 3rd Biennial Meeting, Univ. of Wisconsin-Madison, 30 July - 1 Aug. 1974, p. 26.

Webb, T. III and Douglas R. Clark (1974). On the Use of Tree-Rings, Pollen and Marine Plankton in Reconstructing Past Climates, Abstracts, AMQUA, 3rd biennial Meeting, Univ. of Wisconsin-Madison, 30 July - 1 Aug. 1974, p. 126.

Webb, T. III and J.H. McAndrews (1975). Corresponding Patterns of Contemporary Pollen and Vegetation in Central North America, Geological Society of America Memoir, No. 145 (in press).

Webb, T. III, J. Imbrie and D. Clark (1975). Calibrating Micropalynological Data in Climatic Terms: A Critical Review. Micropaleontology (in prep.).

Webb, T. III, H.J.B. Birks and A.A. Berti (1975). Numerical Analysis of Surface Pollen Samples from Central Canada: A Comparison of Methods. Review of Palaeobotany and Palynology (in press).

Wendland, Wayne M. (1975). An Objective Method to Identify Missing or False Rings. Tree-Ring Bulletin (in press).

Wendland, W.M. (subm. for publ.) Wisconsin Tree Growth from AD 1700 and Tree Response to Climate.

Wendland, Wayne M. (in preparation). Climatic History of Russian America (Alaska) from the Early Nineteenth Century.

Wendland, W.M. and M. Woodworth (1975). Notice of "Data Bank of Early Climatological Sources."